

Foreword

This book describes recent developments in high performance thermoplastic resins and their composites and assesses the benefits and limitations of these emerging materials for aerospace and other applications. Discussions on the performance of neat and continuous fiber reinforced thermoplastic resins in terms of their properties and environmental and chemical resistance are provided. The interrelationships between morphology and properties of semicrystalline thermoplastic composites are addressed as well as the factors influencing the morphology. The various techniques to combine fibers and matrix, to produce high quality laminates, to form three-dimensional parts and to join thermoplastic composite parts are described. One section is devoted to presenting some examples of aircraft applications of thermoplastic composites. General conclusions and recommendations for future research and development work are made.

Recently, a range of commercial composites based on thermoplastic matrix resins have been developed for high-temperature structural applications. These new thermoplastic composites are based on aromatic polymers and surmount the major limitations of earlier aliphatic based thermoplastic polymers such as low elastic modulus, low glass transition temperature and poor solvent resistance. The replacement of metallic and fiber reinforced thermoset components with thermoplastic based composites is now emerging. Although they are not likely to completely replace thermosets, at least in the near future, they offer potential advantages over thermosets for demanding applications (that reinforce the competition between these two classes of advanced reinforced plastics). In general, thermoplastics have an indefinite shelf life, low moisture adsorption, good thermal stability, high toughness and damage tolerance, short and simple processing cycles, and potential for significant reductions in manufacturing costs. In addition, they have the ability to be remelted and reprocessed.

The materials considered here include thermoplastic polymers belonging to various chemical classes such as polyketones, polyarylene sulfides, polyamides, polyimides, polysulfones, liquid crystalline polymers, polybenzimidazoles and polyphenylquinoxalines. The main characteristics of these families are discussed.

The first part of the book reviews the thermal and mechanical properties of the neat thermoplastic resins as well as their chemical and moisture resistance and toughness properties.

The second part of the book concerns the performance of advanced thermoplastics reinforced with continuous carbon fiber. Mechanical properties, interlaminar fracture toughness, damage tolerance, fatigue and creep behavior, resistance to ionizing radiation and thermal cycling as well as the mechanisms of failure are presented. Some comparisons with current epoxy, tough-

ened epoxy and bismaleimide based composites are made. A section is devoted to the influence of morphology of semicrystalline thermoplastics on the properties of the composites, and the factors influencing the morphology of semicrystalline thermoplastics are addressed as well.

Although the questions of processing techniques, tooling, joining and repairing have not been fully addressed by researchers and industrial engineers, applications of thermoplastic composites are increasingly popular. Some primary and secondary structures have been manufactured and flight tested. Practical experiences in the aircraft and aerospace fields are reviewed to assess the processing and performance benefits of thermoplastic composites. The book presents conclusions and recommendations regarding the potential of thermoplastic composites for aircraft structural applications, especially in comparison with thermoset based composites.

The information in the book is from *A Review of High Performance Thermoplastic Resins and Their Composites*, by Sylvie Béland of the Institute for Aerospace Research of the National Research Council of Canada, for the National Research Council of Canada, February 1990.

The table of contents is organized in such a way as to serve as a subject index and provides easy access to the information contained in the book.

Advanced composition and production methods developed by Noyes Data Corporation are employed to bring this durably bound book to you in a minimum of time. Special techniques are used to close the gap between "manuscript" and "completed book." In order to keep the price of the book to a reasonable level, it has been partially reproduced by photo-offset directly from the original report and the cost saving passed on to the reader. Due to this method of publishing, certain portions of the book may be less legible than desired.

ACKNOWLEDGMENTS

The author would like to thank Mr. R.F. Scott, Mr. S. Lee and Dr. W. Wallace from the Institute for Aerospace Research, National Research Council of Canada for valuable discussions and the proofreading of this report.

NOTICE

The materials in this book were prepared as accounts of work sponsored by the National Research Council of Canada. On this basis the Publisher assumes no responsibility nor liability for errors or any consequences arising from the use of the information contained herein. Mention of trade names or commercial products does not constitute endorsement or recommendation for use by the Council or the Publisher.

Final determination of the suitability of any information or procedure for use contemplated by any user, and the manner of that use, is the sole responsibility of the user. The reader is warned that caution must always be exercised when dealing with potentially hazardous materials and processes, and expert advice should be sought at all times.